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FINAL REPORT
JULY 1993

REPORT NO. 93-15

ARMORED CRAWLER TRACTOR
AND RAKE
RAIL TRANSPORTABILITY
AND TIEDOWN PROVISION
PULL TESTS

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Prepared for:
U.S. Army Tank-Automotive Command
ATTN: AMSTA-UED
Warren, MI 48937-5000

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| 19. ABSTRACT (Continue on reverse if necessary and identify by block number) The U. S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Tank-Automotive Command, AMSTA-UED, to perform rail transportability and tiedown provision pull tests on the T-9 MCAP armored crawler tractor and rake. The armored crawler tractor with blade attached and demountable rake on pallet were tested 13-14 July 1993. The tractor and rake were cabled to a flatcar for rail transportability testing. No damage was sustained by the tractor or rake. Pull testing was not completed due to sharp edges in the armor on the roof of the tractor. The sharp cutting edges severed or damaged the wire rope cables used to perform the pull tests. Since these cables were cut, the edges on the tractor were considered a safety hazard when trying to sling the tractor; therefore, the pull test failed. The rake was not pull tested as it did not have any clearly identified tiedown provisions as required by MIL-STD-209H, Military Standard Slings and Tiedown Provisions for Lifting and Tying Down Military Equipment. | | | | | |
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**U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639**

REPORT NUMBER 93-15

**ARMORED CRAWLER TRACTOR AND RAKE RAIL TRANSPORTABILITY
AND TIEDOWN PROVISION PULL TESTS**

JULY 1993

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PART 1

INTRODUCTION

A. **BACKGROUND.** The U. S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by the U.S. Army Tank-Automotive Command, AMSTA-UED, to perform rail transportability and tiedown provision pull tests on the T-9 MCAP armored crawler tractor and rake. Transportation requirements are set forth in TP-91-01, Transportability Testing Procedures (as extracted from MIL-STD-810, Environmental Test Methods), July 1991, and tiedown provision pull tests are delineated in MIL-STD-209H, Military Standard Slings and Tiedown Provisions for Lifting and Tying Down Military Equipment.

B. **AUTHORITY.** This test was conducted IAW mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL 61299-6000. Reference is made to Change 4, 4 October 1974, to AR 740-1, 23 April 1971, Storage and Supply operations; AMCCOMR 10-17, 31 August 1991, Mission and Major Functions of USADACS.

C. **OBJECTIVE.** The objective of these tests is to revalidate rail transportability and tiedown fitting strength. Testing is required after the addition of armor plating increased the gross vehicle weight (GVW) by 10 percent. The rail transportation test requires the tractor to be secured to a friction draft gear flatcar and impacted at 4, 6, and 8.1 mph in the forward direction and one impact at 8.1 mph in the reverse direction. Tiedown provision testing requires pulling the provisions to specific tensions in two or more different directional planes.

D. **CONCLUSION.** The armored crawler tractor and rake satisfied the rail transportation tests of MIL-STD-810. MIL-STD-209H slinging and lifting provision tests were not performed on

the rake because it did not have any provisions as required by the standard. The armored crawler tractor did not comply with MIL-STD-209H due to the sharp edge on the top of the Roll Over Protection Structure (ROPS). This right angle cutting edge damages lifting cables by cutting the strands. As a result of this damage, a cable becomes unsafe for lifting. One cable broke, pointing out that the ROPS top edges are a safety hazard in slinging operations and need to be redesigned.

E. RECOMMENDATIONS.

1. The armored crawler tractor ROPS be redesigned to prevent cutting into the lifting cables.
2. MIL-STD-209H tiedown and slinging provisions be added to the rake. The shipping pallet for the rake be redesigned to withstand rail impact tests and conform to rail impact of MIL-STD-810.

PART 2

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13-14 July 1993

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PART 3

TEST PROCEDURES

A. RAIL IMPACT TESTING:

1. The armored crawler tractor and rake was positioned on a conventional flatcar equipped with friction draft gear. The tractor was secured to the railcar with 5/8-inch wire rope as outlined in MIL-STD-209H. Equipment needed to perform the test included the specimen (hammer) car, five empty railroad cars connected together to serve as the anvil, and a railroad locomotive. The anvil cars were positioned on a level section of track with air brakes set and draft gear compressed. The locomotive unit pulled the specimen car several hundred yards away from the anvil cars, then, pushed the specimen car toward the anvil cars at a predetermined speed, then the locomotive disconnected from the specimen car approximately 50 yards away from the anvil cars, which allowed the specimen car to roll freely along the track until it struck the stationary anvil cars. This constituted one impact.

2. Impacting was accomplished at speeds of 4, 6, and at least 8.1 mph in one direction and at a speed of at least 8.1 mph in the opposite direction. The 4 and 6 mph speeds were approximate; the 8.1 mph speed was a minimum. Impact speeds were determined by using an electronic counter to measure the time required for the specimen car to traverse an 11-foot distance immediately prior to contact with the anvil cars.

3. At selected intervals during testing, thorough inspections of the specimen loads were made by technically-proficient personnel to collect data on the specimen load and equipment resulting from the test steps above. The data are recorded in part 4.

B. MIL-STD-209H PULL TESTS.

1. All armored crawler tractor slinging and tiedown provisions were tested attached to the equipment. For test purposes, only wire rope, wire rope with a thimble loop, chain, or a shackle attached to the provision was used. Textile straps, such as nylon and polyester (Dacron) and synthetic ropes, were not used. The loads applied during testing were less than the design limit load requirement and not more than 10 percent in excess.

2. The armored crawler tractor provisions are type class 3, serving as slinging (class 1) and tiedown (class 2) provisions; therefore, testing of each unique fitting was required.

3. Slinging provision tests are as follows:

a. A static pull to the required design limit load was conducted on all provisions; however, all provisions did not have to be tested at the same time.

b. Crane Lifting requirements:

(1) A design limit load of not less than 2.3 times the static load was applied.

(2) The static load was determined by mathematical analysis based on the sling legs converging at the apex to form 45-degree vertical angles, or on sling legs with lengths not longer than 12 feet, whichever is less severe when the item is suspended in a level attitude.

(3) An ultimate load of not less than 1.5 times the design limit loads was applied.

c. The points used to apply the load to the equipment were located so they did not interfere with or reduce the loading on the structural member next to the provisions.

d. Loads in the sling legs were measured with an appropriate measuring device, such as a load cell or dynamometer.

e. The load applied to each provision was not less than the required design limit load and was applied for not less than 90 seconds.

f. No visible permanent deformation or set in the provision or other equipment structural components resulted from application of the loads to the provisions. When measuring devices were used, deformation did not exceed a 0.2 percent offset. Weld cracks constitute test failure.

4. Tiedown provision tests are as follows:

a. Loads were applied to each provision and measured with an appropriate measuring device, such as a load cell or dynamometer.

b. The points used to apply the load to the equipment were located so they did not interfere with or reduce the loading on the structural member next to the tiedown provision.

c. Loads were applied in the longitudinal, vertical, and lateral directions. Each load was applied statically for a period of not less than six seconds and was not less than the required load for the tested direction.

d. No visible permanent deformation or set in the provisions or other equipment structural components resulted from application of the loads to the provisions. When measuring devices or gages were used, deformation did not exceed a 0.2 percent offset. Weld cracks constitute test failure.

PART 4

TEST RESULTS

Test No.: 1

Date: 13-14 July 1993

Rail Impact Data

Specimen Load: Armored Crawler Tractor and Rake

Flatcar No: BN 602916

Lt. Wt.: 58,120 pounds

Armored Crawler Tractor

Wt.: 56,750 pounds

Rake

Wt.: 3,750 pounds

Total Specimen Wt.: 118,620 pounds

Buffer Car (five cars) Wt.: 250,000 pounds

| <u>Impact</u> | <u>End Struck</u> | <u>Velocity</u> | <u>Remarks</u> |
|----------------------|--------------------------|------------------------|--|
| 1 | Forward | 4.36 | No movement of tractor or rake. |
| 2 | Forward | 6.62 | Tractor tracks moved 1/4-inch from rear chock. |
| 3 | Forward | 8.52 | Track moved an additional 1/4-inch from rear chock. |
| 4 | Atf | 8.93 | Track recovered 1/2-inch from chock to 1/2-inch at forward chock. Cables loosened due to cutting into wooden flatcar deck. |

Test No.: 2

Date: 7-11 July 1993

Armored Crawler Tractor Provision Tests

1. Slinging pull test.

- | | |
|---------------------------------|-----------------|
| a. Total required pull at apex. | 130,525 pounds. |
| b. Two front provisions. | 38,823 pounds. |
| c. Two rear provisions. | 51,686 pounds. |

Due to limited pulling capabilities, each provision would be pulled to the required load of test procedure 1.b. or 1.c., as required. The sling leg length was limited to 12 feet and an angle of 45 degrees over the armored Roll Over Protection Structure (ROPS). With this configuration, the right rear provision was pulled to 49,000 pounds (this was the pulling limit with the equipment onhand). The one-inch wire rope used in testing experienced cut wire strands where the cable went over the top edge of the ROPS. A second slinging pull test was performed on the forward slinging provision. The maximum tension was 20,000 pounds, at which point the one-inch wire rope sling broke. The break was caused by the sharp, right angle corner of the ROPS. As a result of these tests, it was determined that a safety hazard existed when trying to lift the tractor with a 12-foot sling. The safety hazard is sufficient enough to cause failure in the testing sequence and not being able to meet MIL-STD-209H test standards.

2. Tiedown pull test.

- | | |
|--------------------------|----------------|
| a. Forward and aft pull. | 56,750 pounds. |
| b. Vertical. | 28,375 pounds. |
| c. Lateral. | 42,563 pounds. |

The right rear tiedown fitting was pulled vertically to 58,120 pounds and held for a period of 90 seconds without deformation. No other pull tests were performed.

Test No.: 3

Date: 7-11 July 1993

Armored Crawler Tractor Rake Provision Tests

1. Slinging pull test.

- | | |
|---------------------------------|---------------|
| a. Total required pull at apex. | 8,545 pounds. |
| b. Right front provision. | 4,132 pounds. |
| c. Left front. | 2,767 pounds. |
| d. Left rear. | 1,208 pounds. |
| e. Right rear. | 1,267 pounds. |

2. Tiedown pull test.

- | | |
|--------------------------|---------------|
| a. Forward and aft pull. | 7,430 pounds. |
| b. Vertical. | 1,858 pounds. |
| c. Lateral. | 2,786 pounds. |

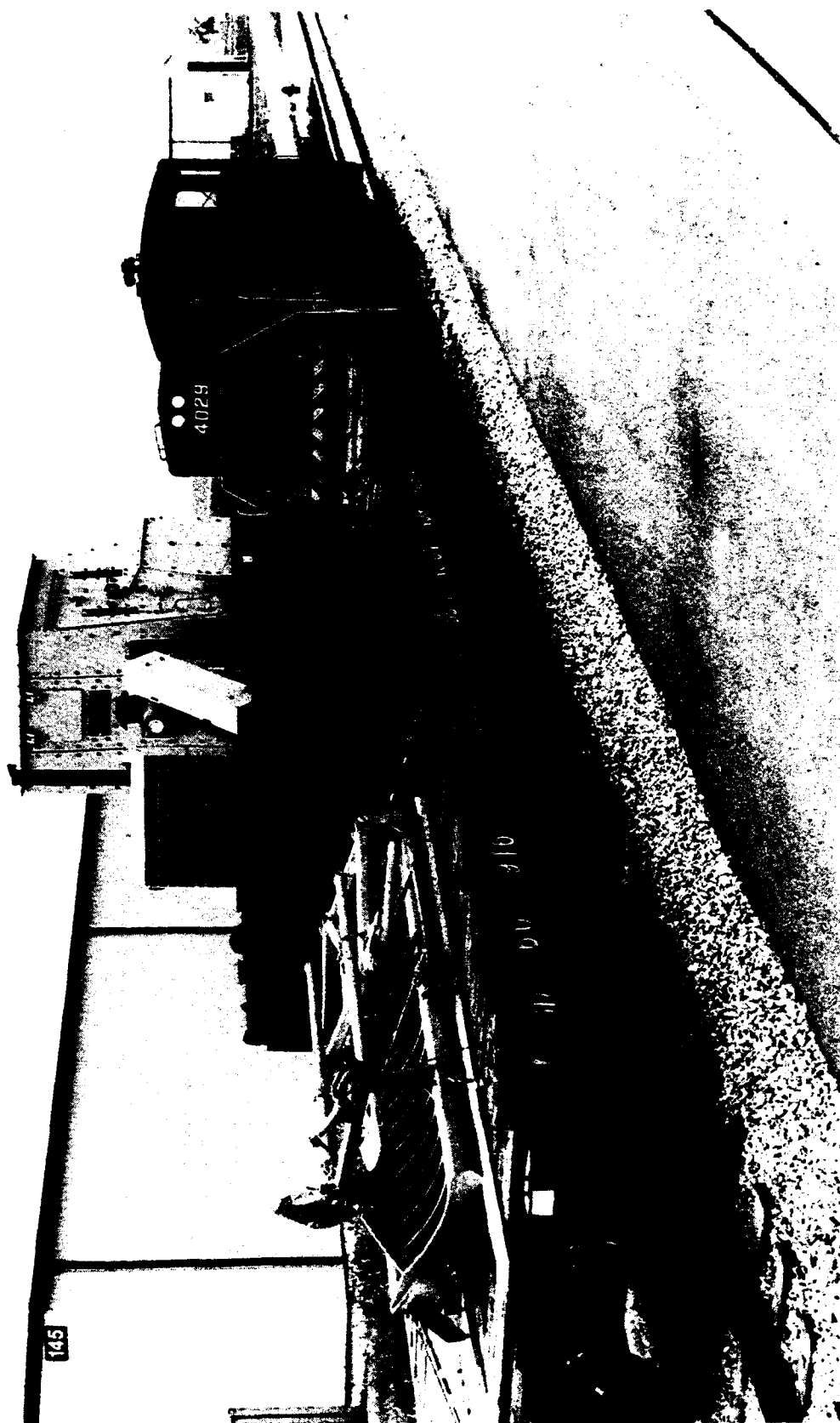
MIL-STD-209H requires that tiedown and lifting provisions be clearly marked and of a recommended design. The rake did not have either of the following:

- a. Any markings that identified a tiedown point.
- b. Any provisioning that could be identified with the recommendations of MIL-STD-209H.

Thus, no slinging or tiedown tests could be accomplished on the rake.

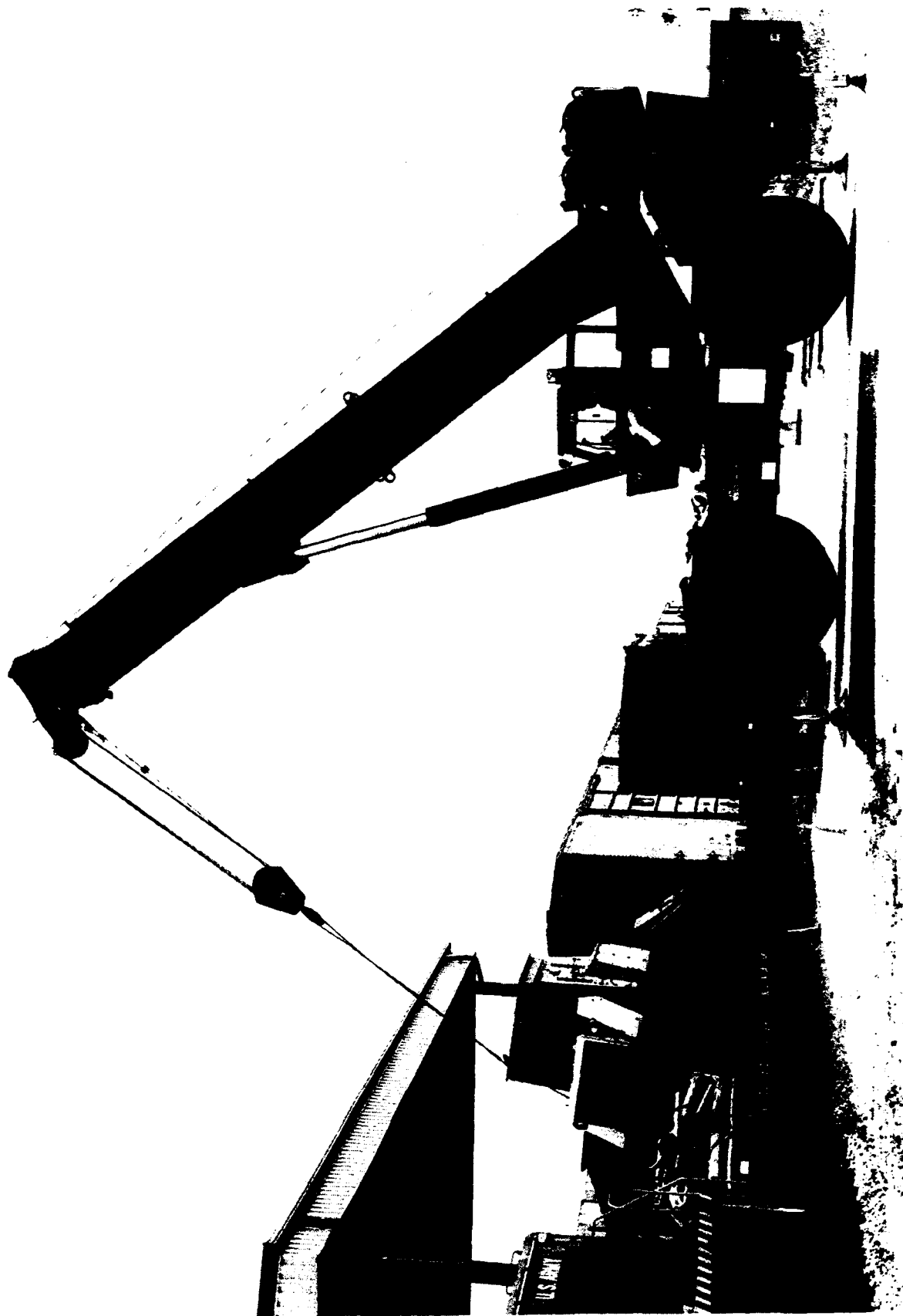
PART 5

PHOTOGRAPHS



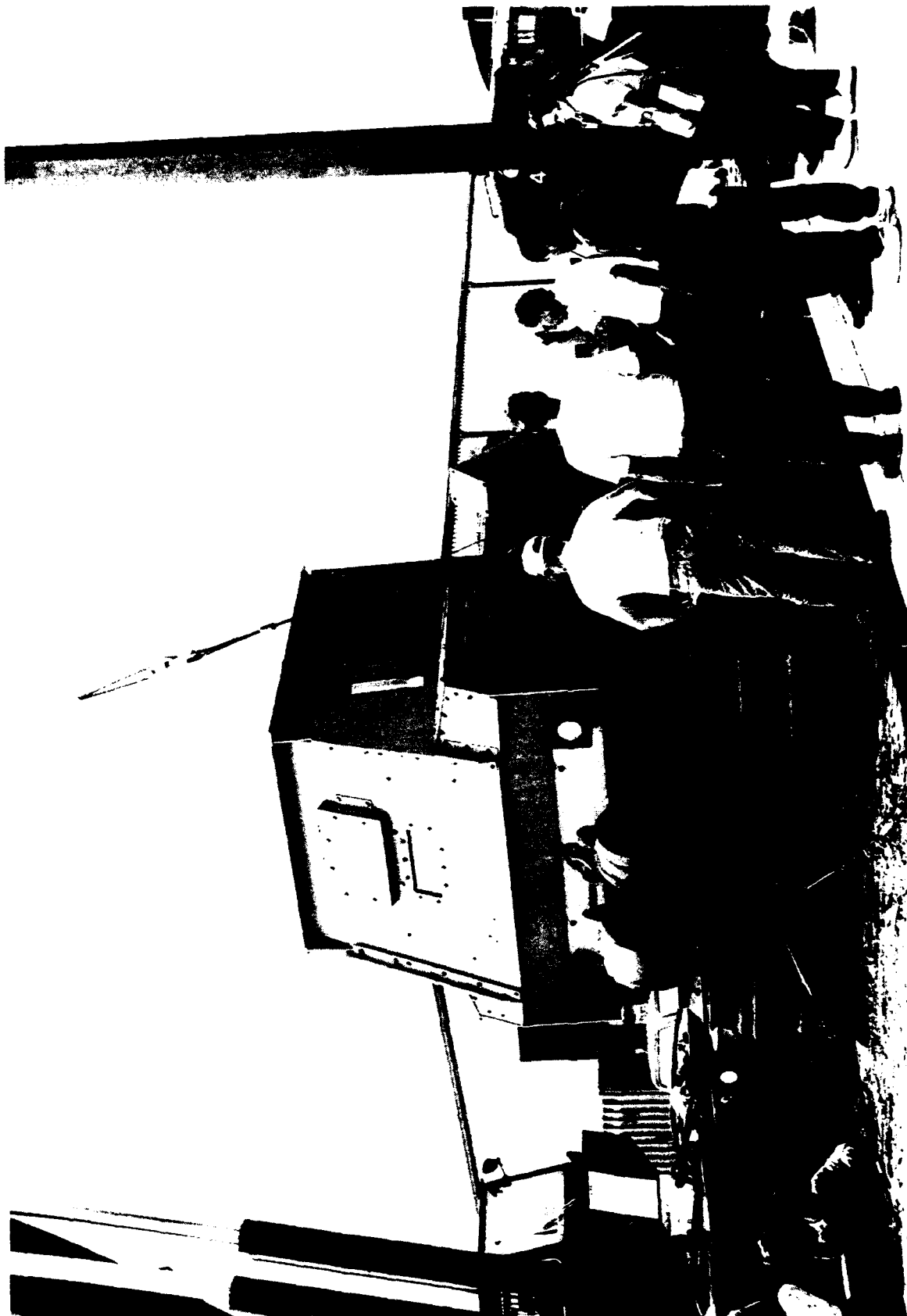
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SPN-93-213-4013. This photo shows the T-9 MCAP armored crawler tractor and rake being positioned for rail impact. The rake assembly was expediently secured to the railcar due to the lack of a substantial pallet and tiedown provisions.



| | | |
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SPN-93-213-4008. This photo shows the 40-ton crane used for pulling the tiedown and lifting provisions on the armored crawler tractor.

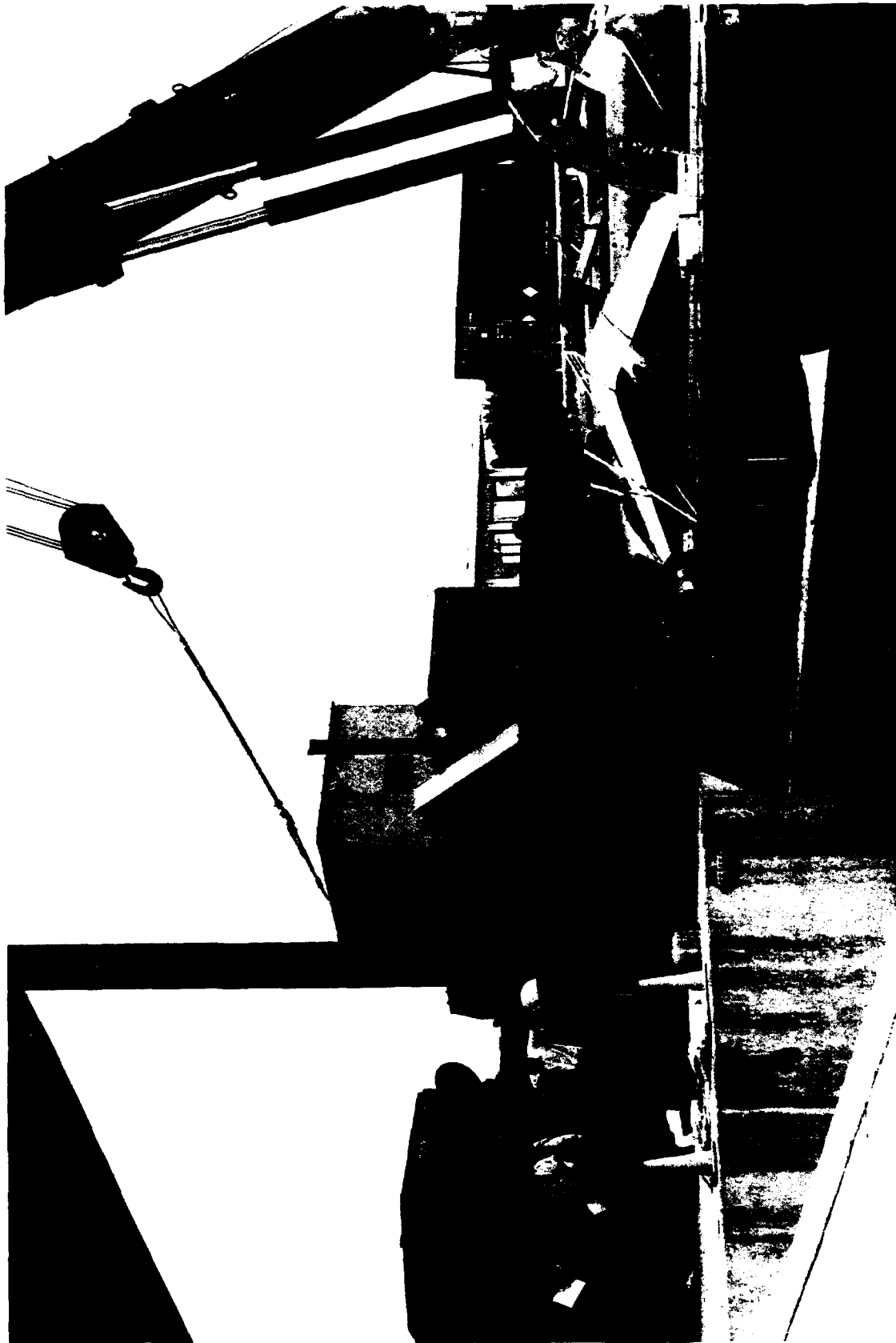


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SPN-93-213-4026. This photo shows the rear of the armored crawler tractor. A pull test is in progress.



| | |
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| | U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL |
| | SPN-93-213-4006. This photo shows the locomotive and buffer cars aiding in anchoring the specimen car when it was used as a counterweight during provision pull tests. |



| | | |
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| | | |
|--|---|--|
| | SPN-93-213-4021. With the shear edge on the Roll Over Protection Structure (ROPS), a 12-foot, four-legged sling will be cut while trying to lift the armored crawler tractor. The center of the sling is approximately 18 inches above the top of the roof. | |
|--|---|--|



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SPN-93-213-4010. This photo shows the edge contact with the lifting sling and the armored crawler tractor ROPS. This cable was replaced due to cut strands.

PART 6

TIEDOWN PROCEDURES

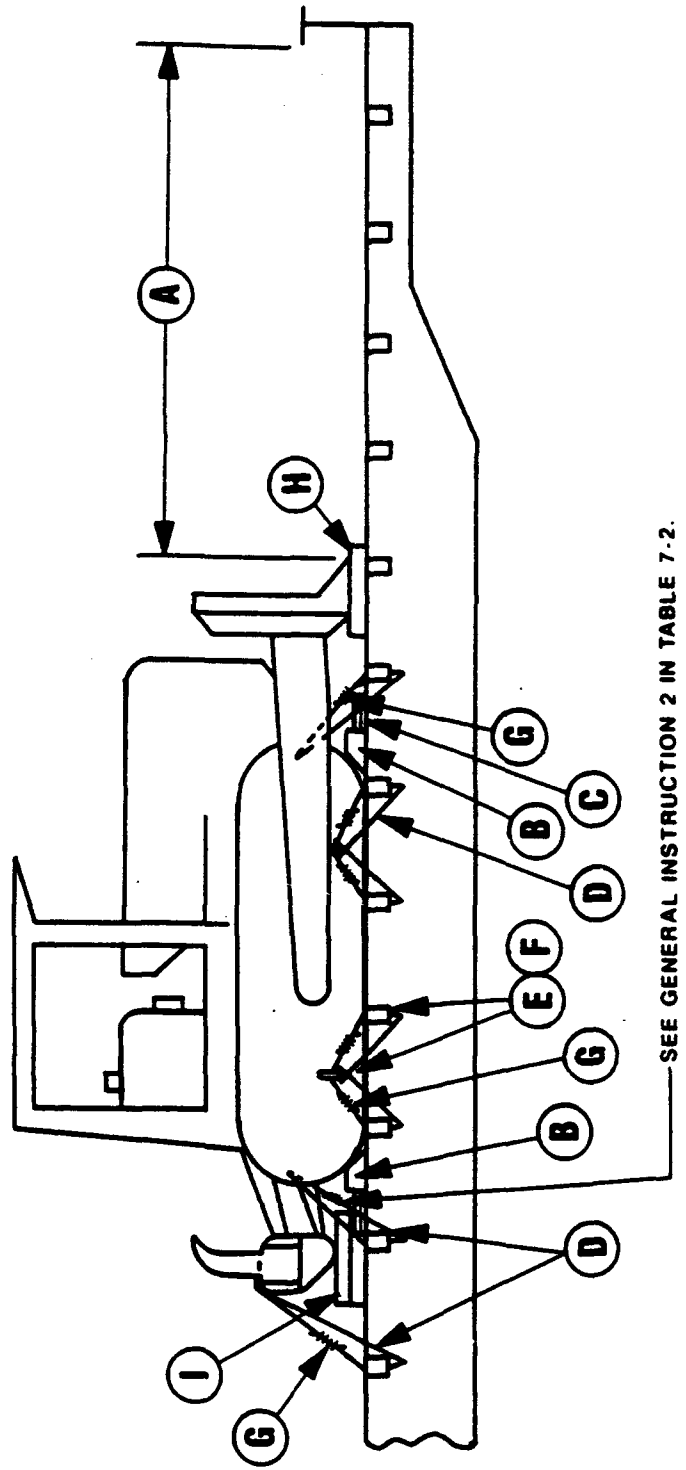
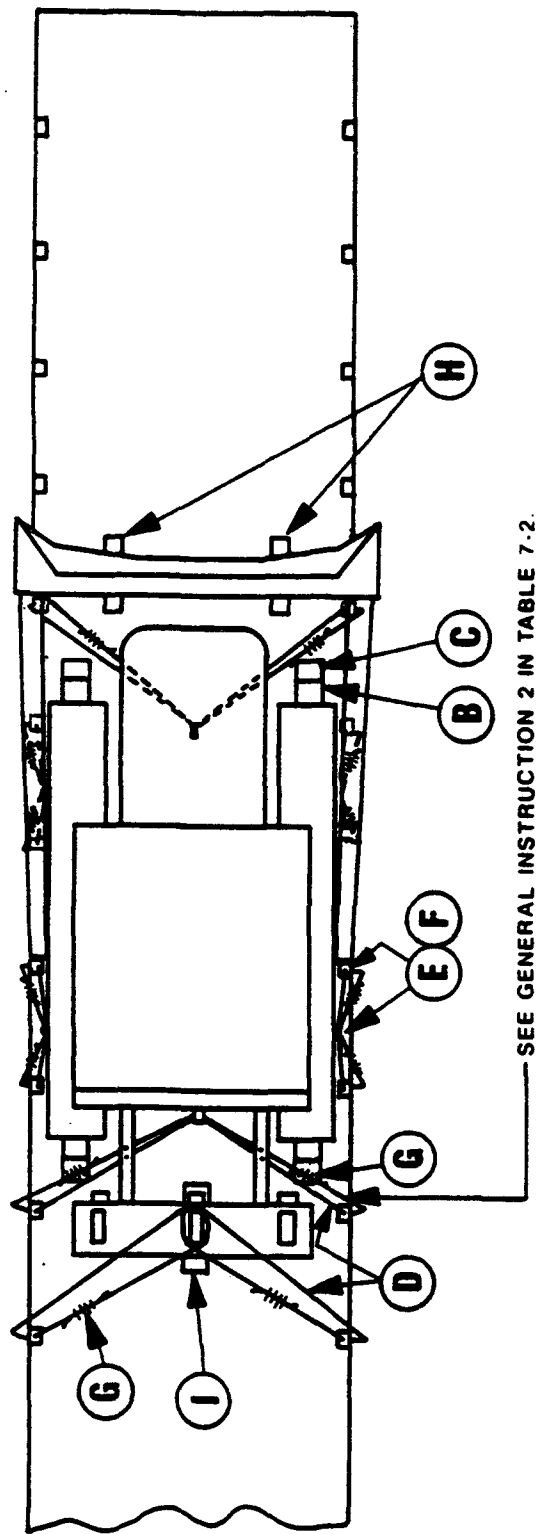
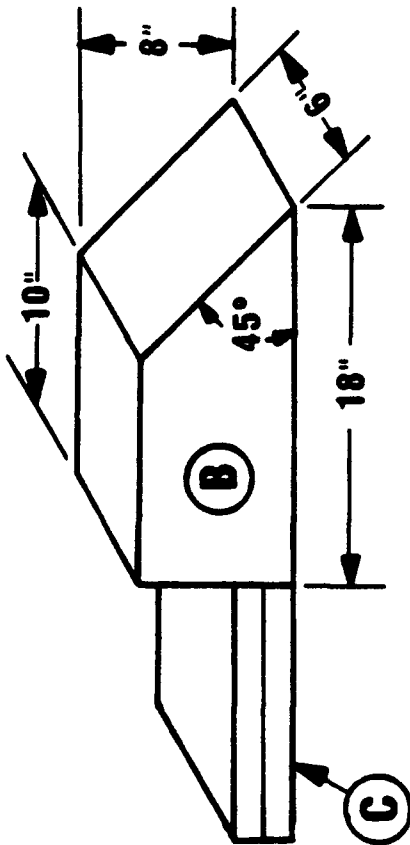
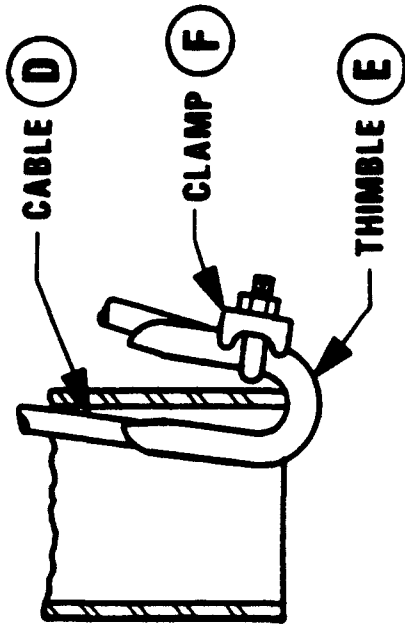


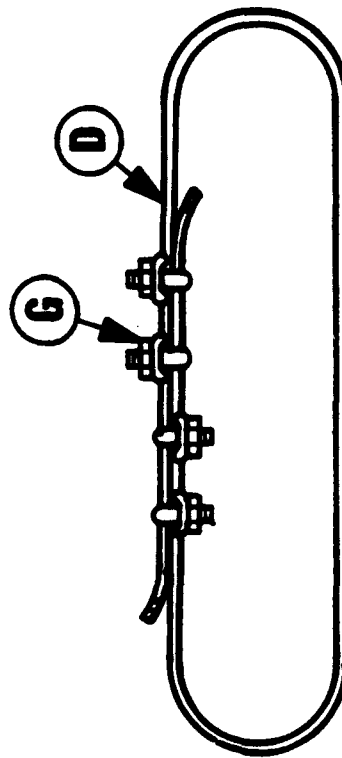
Figure 7-1. D7 crawler tractor loaded on a CONUS general-purpose flatcar (table 7-2 and figure 7-2).



DETAIL 1



DETAIL 2



DETAIL 3

Figure 7-2. Blocking and tiedown details (table 7-2 and figure 7-1)

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Table 7-1. Bill of Materials for Blocking and Tiedown of the D7 Crawler Tractor on a CONUS General-Purpose Flatcar (Figs 7-1 and 7-2)

| Item | Description | Approximate Quantity |
|-----------|--|----------------------|
| Lumber | Oak or comparable hardwood, straight-grain, free from material defects; type II, Fed Spec MM-L-736: 4- by 8-inch | 10 linear feet |
| Lumber | Douglas-fir, or comparable, straight-grain, free from material defects; Fed Spec MM-L-751: 2- by 6-inch | 12 linear feet |
| | 6- by 8-inch | 8 linear feet |
| Nails | Common, steel, flathead; bright or cement-coated; Fed Spec FF-N-105: 30d | 34 |
| Wire rope | 6 × 19, IWRC; improved plow steel; preformed, regular-lay; Fed Spec RR-W-410: ½-inch | 142 feet |
| Clamps | Wire rope, U-bolt clips, saddled, single-grip, steel, Crosby heavy-duty, or equal; Fed Spec FF-C-450: ½-inch | 48 |
| | ¾-inch | 20 |
| Thimbles | Standard, open-type: ½-inch | 20 |

Table 7-2. Application of Materials for Blocking and Tiedown of the D7 Crawler Tractor on a CONUS General-Purpose Flatcar (Figs 7-1 and 7-2)

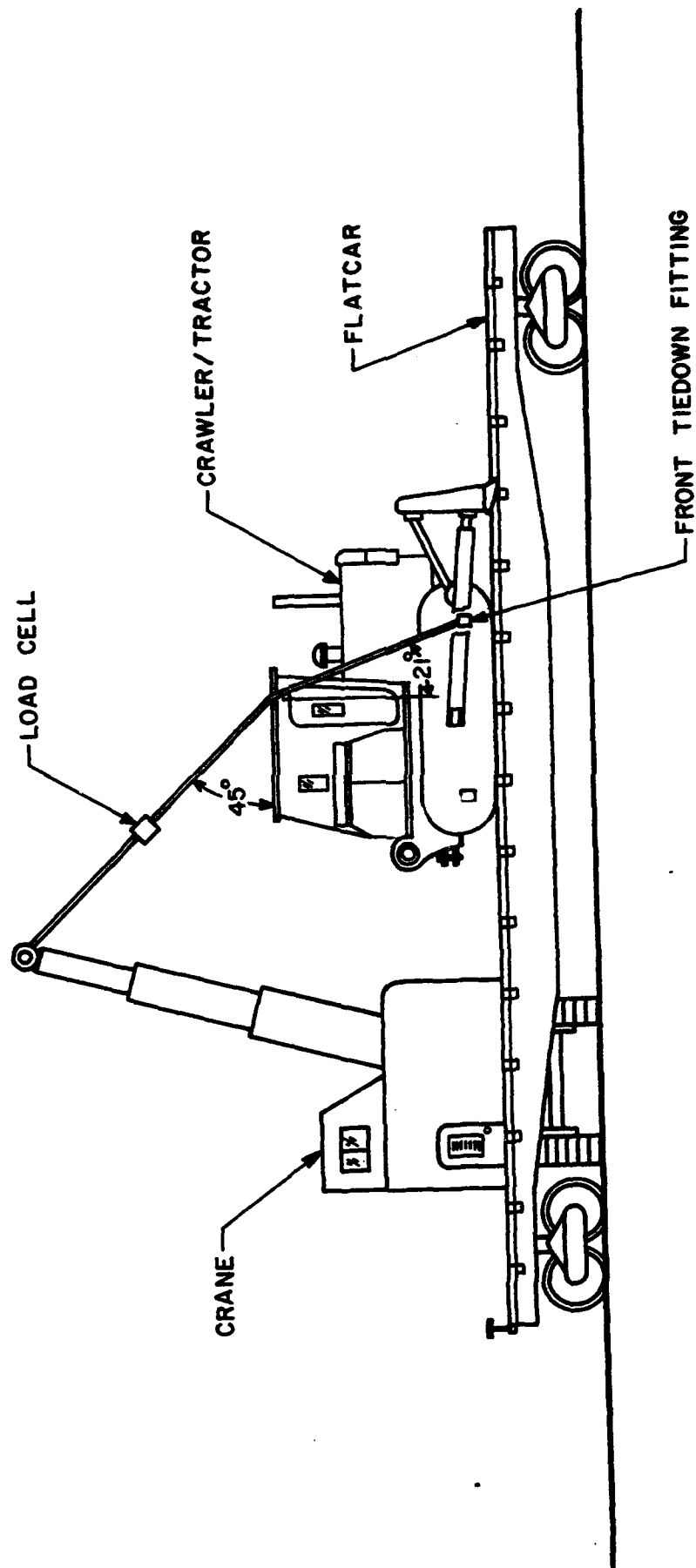
| Item | No. Required | Application |
|------|--------------|---|
| A | | Brake-wheel clearance. Minimum clearance required is 6 inches above, in back of, and on both sides of and 4 inches underneath wheel; 12 inches from end of railcar to load, which extends from center of brake wheel to side of railcar; and 6 feet above railcar floor. |
| B | 4 | Track chocks. Each consists of 6- by 8- by 18-inch block cut as shown in detail 1, figure 7-2. Place one chock firmly against the center of each track at the forward and rear ends of the tractor. Place chock with the 45° cut angle edge toward the track. Toenail each chock with four 30d nails. |
| C | 4 | Backup cleats. Use two pieces of 2- by 6- by 18-inch lumber for each track chock. Place against each track chock, item B. Nail bottom piece with three 30d nails in staggered pattern and nail top piece with three 30d nails in like manner. |
| D | 12 | Wire rope, ½-inch, 6 × 19, IWRC. Form wire rope in a complete loop. Apply from left and right tiedowns, forward towing hook, and around the center ripper shank on top of the tool block on the track-type tractor to stake pockets. Wire tie hook and pin to retain wire rope, if necessary. Overlap wire rope at least 24 inches (details 2 and 3, fig 7-2). See general instruction 2. |
| E | 20 | Thimbles. Place thimbles at the side tiedowns and the bottom of each stake pocket. |

| | | |
|---|----|---|
| F | 20 | Clamps. Fasten thimbles to wire rope with ¾-inch cable clips to prevent dislodgement. |
| G | 48 | Clamps. Fasten each wire rope tiedown with four ¾-inch wire rope clips spaced about 3-½ to 4 inches apart. Torque ¾-inch clips to 90-foot-pounds. |
| H | 2 | Lumber, oak, 4- by 8- by 30-inch. Raise blade and place one piece of lumber lengthwise, about 36 inches from each end of blade. Drill and toenail each piece of lumber to railcar floor with four 30d nails. Lower blade on top of blocking and lock hydraulic cylinders into position. |
| I | 2 | Lumber, oak, 4- by 8- by 30-inch. Raise rear ripper for placing the two pieces of lumber stacked one on another in the center of the ripper. Place a 30-inch piece lengthwise on railcar. Drill and toenail first piece of lumber to the railcar floor with four 30d nails. Then drill and toenail second piece on top of first with four 30d nails. Lower ripper on top of blocking. |

GENERAL

1. Brakes must be tightly set and secured.
2. Tractors without ripper must have the rear left and right tiedowns attached to the rear towing pin. Maintain similar angles on tiedowns as shown on drawing.
3. General Loading Rules 1, 2, 4, 5, 7, 9, 14, 15, 19, 19A, and 19B appearing in section 1 of the *Rules Governing the Loading of Commodities on Open-Top Cars*, published by the Association of American Railroads, provide guidelines that are mandatory in application.

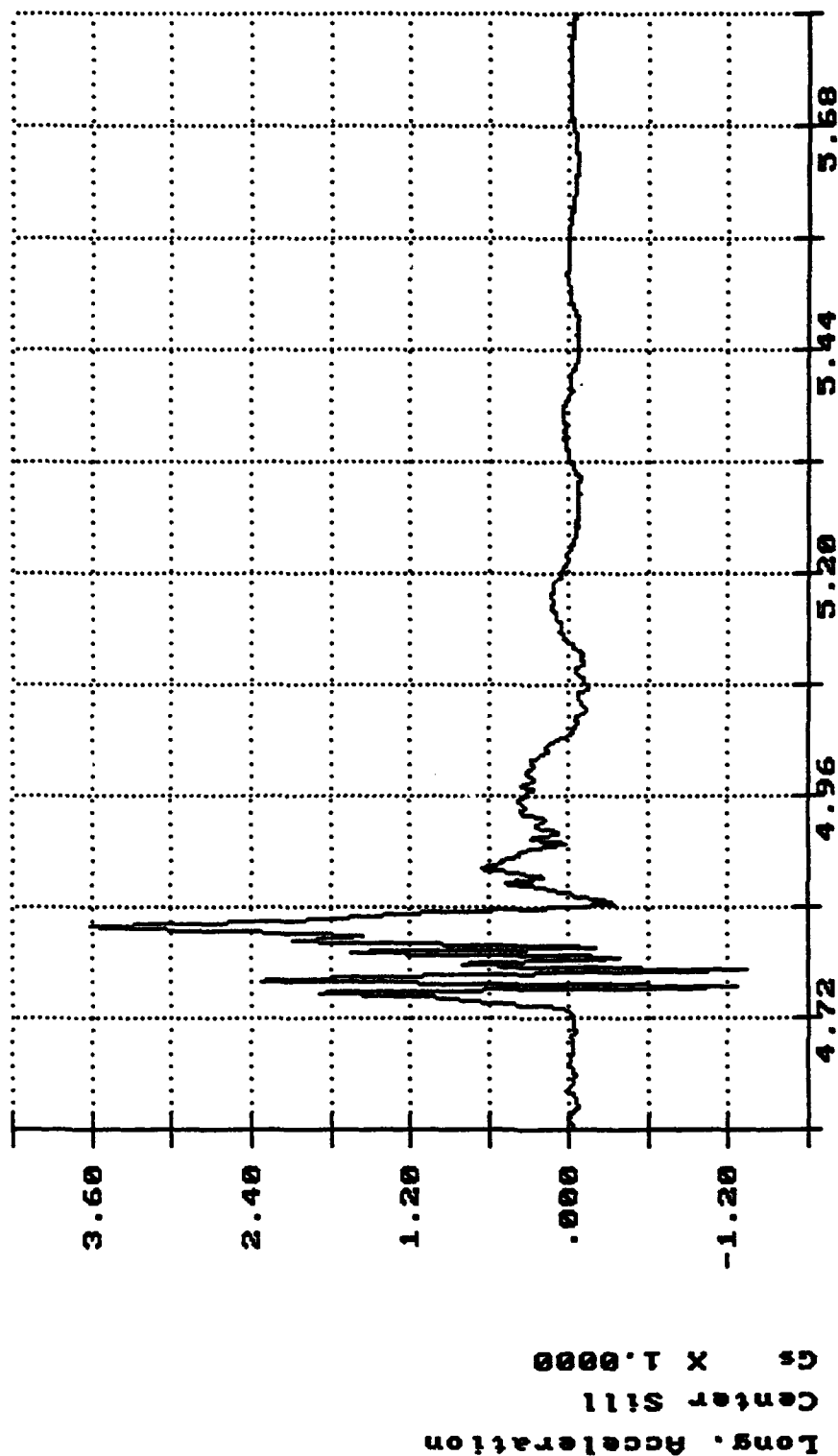
c. Wooden-deck chain-tiedown flatcars, usually are equipped with four parallel channels that run the full length of the flatcar deck. Two channels are about 30 inches apart, and two other channels run along the outer edges of the car, or just inboard of the tread-way loading area of the car. These channels are recessed so that the top is flush with the deck surface. Each channel contains numerous (usually 8 to 12) chain anchors, each with an attached 10- to 12-foot chain. The chain anchors can be moved along the channel and locked in place where needed. At the free end of the chain, pass a hook through the tiedown shackle on the vehicle being loaded and pull the chain hand-tight. Then hook it back onto itself or directly to the shackle. Apply tension to the chain by tightening a turnbuckle built into the chain assembly or by turning a ratchet or screwjack in the anchor block. Use an open-end wrench to tighten the turnbuckles. Use a ¾-inch square-drive, heavy-duty socket wrench to tighten the ratchet at the anchor blocks. Wire-tie open hooks to prevent them from becoming disconnected during over-the-road forces encountered en route. Table 7-3 gives the application of materials for tiedown of the D7 tractor on wooden-deck chain-tiedown flatcars.



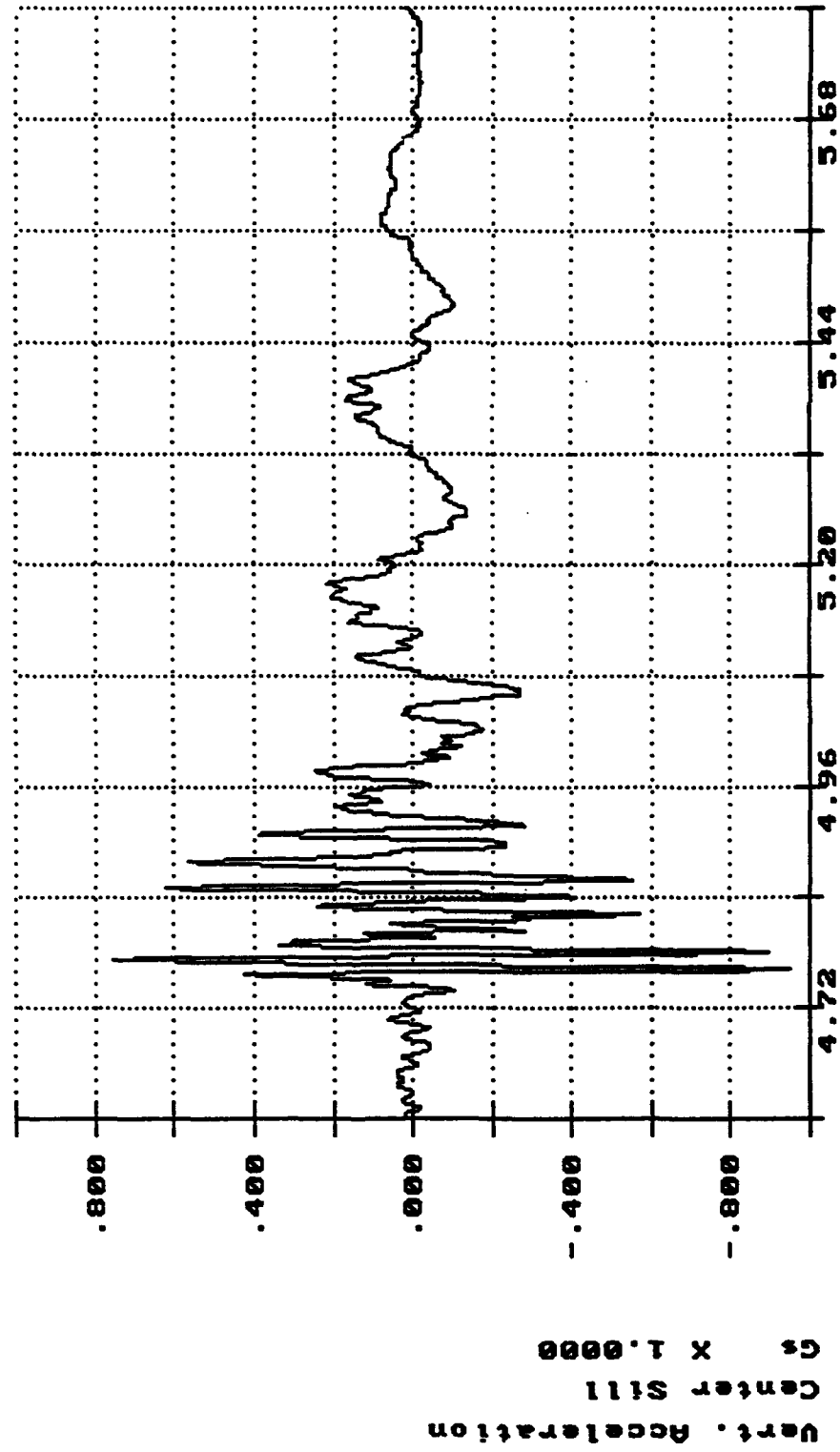
PART 7

GRAPHS

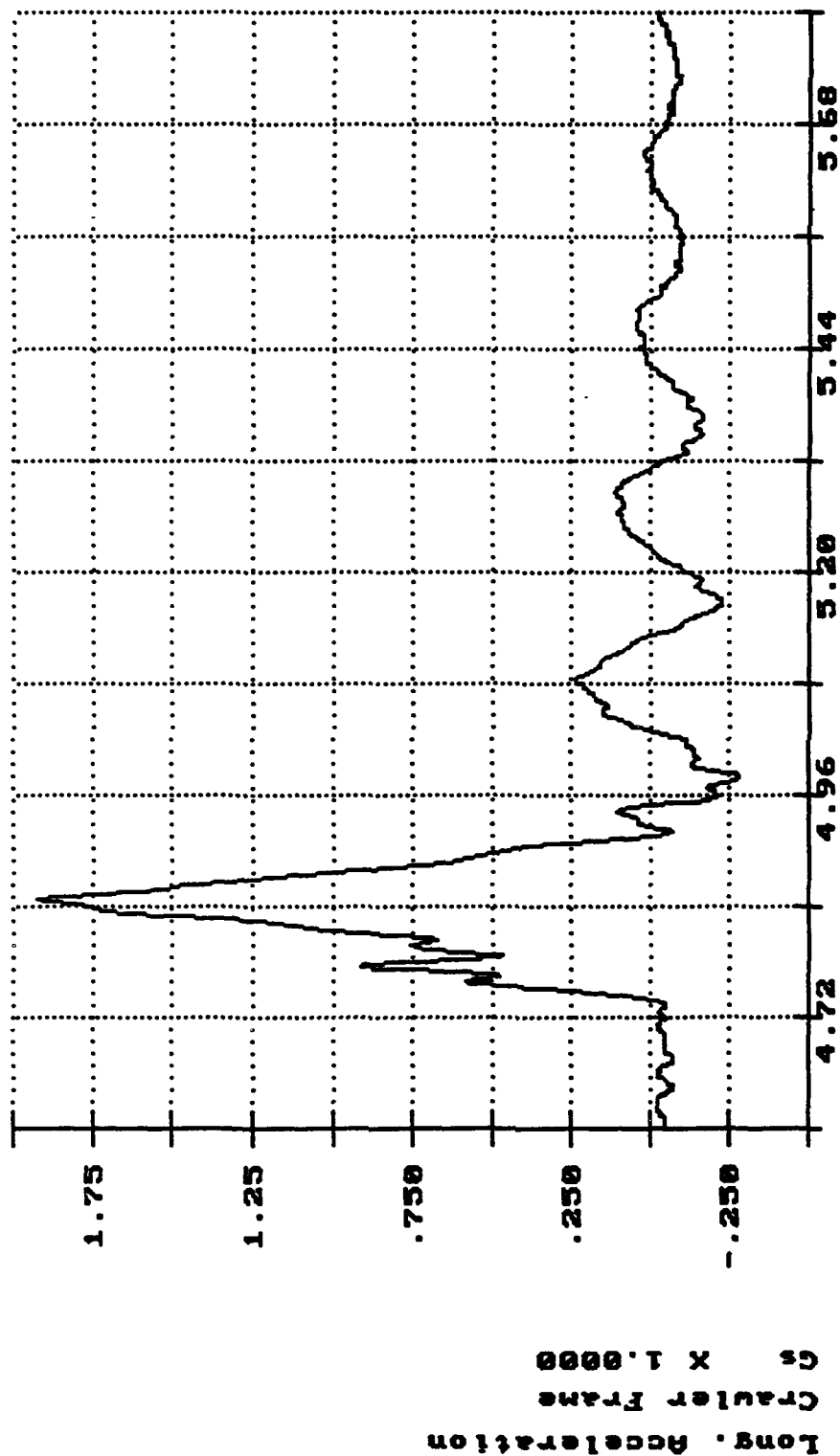
R.I. of Armored Crawler, #1: 4.36 MPH Jul 13 09:12:05 1993



R.I. of Armored Crawler, #1: 4.36 MPH Jul 13 09:12:05 1993



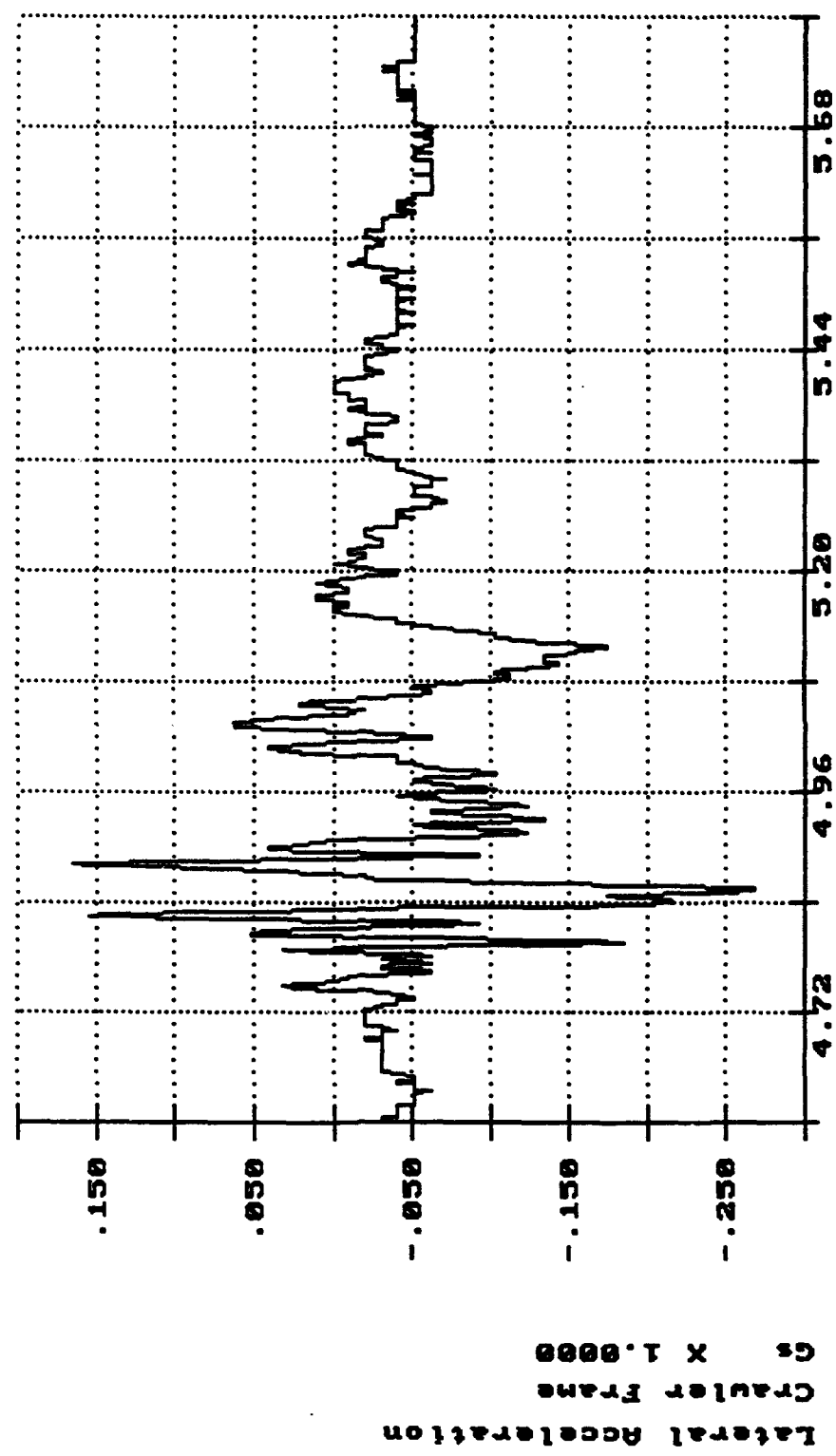
R.I. of Armored Crawler, #1: 4.36 MPH Jul 13 09:12:05 1993



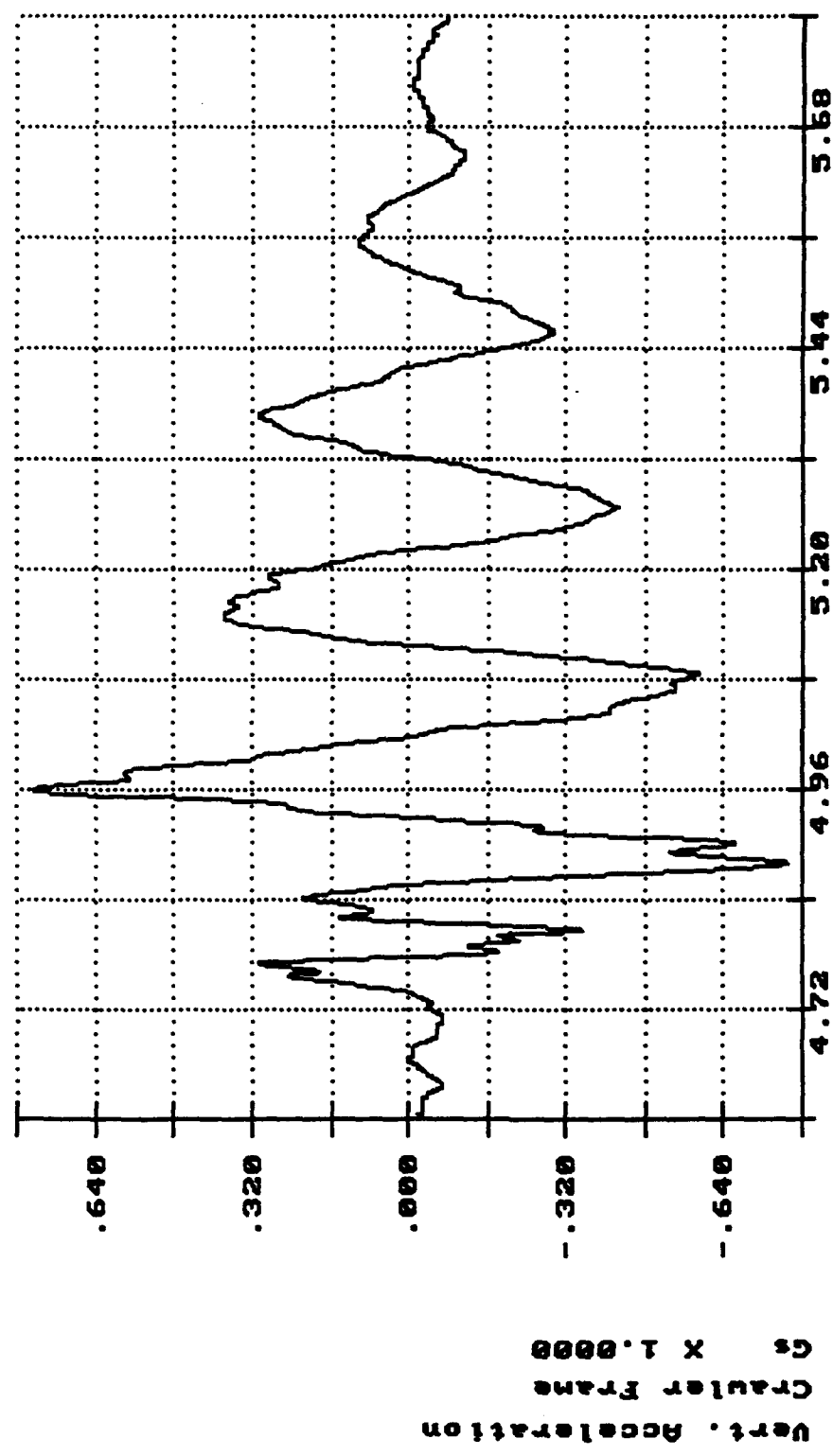
Time of Sample

Seconds X 1.0000

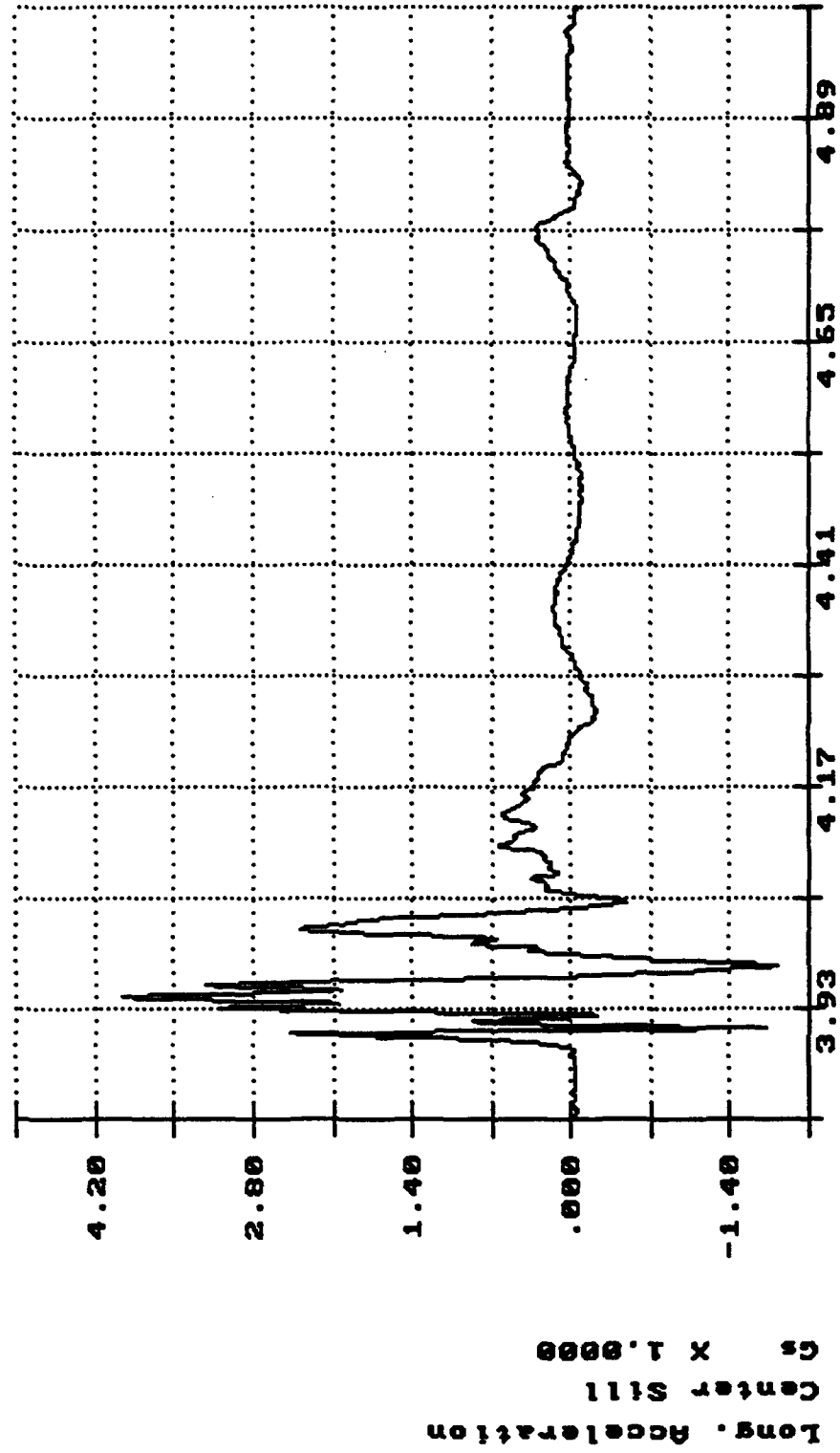
R.I. of Armored Crawler, #1: 4.36 MPH Jul 13 09:12:05 1993



R.I. of Armored Crawler, #1: 4.36 MPH Jul 13 09:12:05 1993



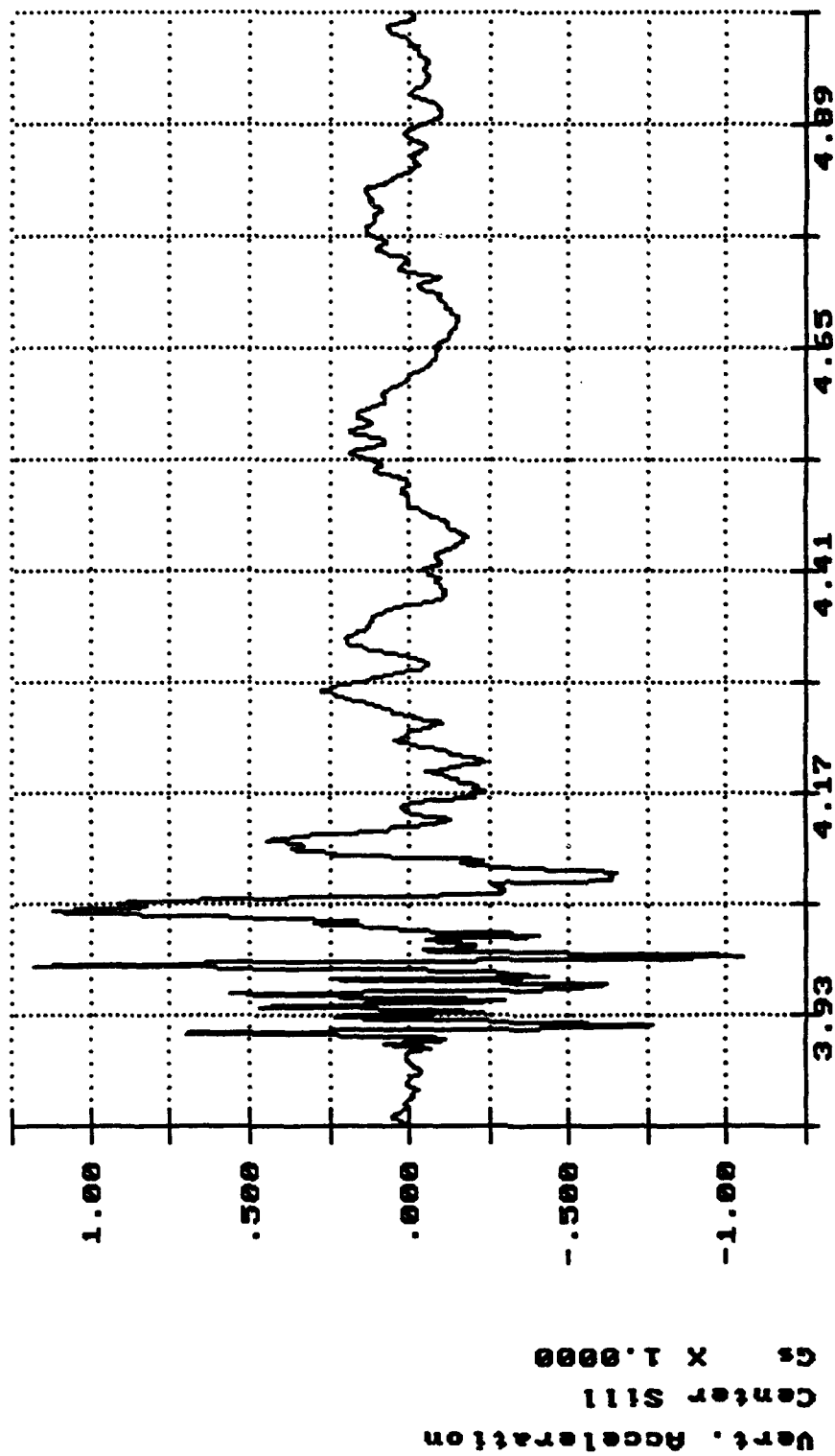
R.I. of Armored Crawler, #2: 6.62 MPH Jul 13 09:19:04 1993



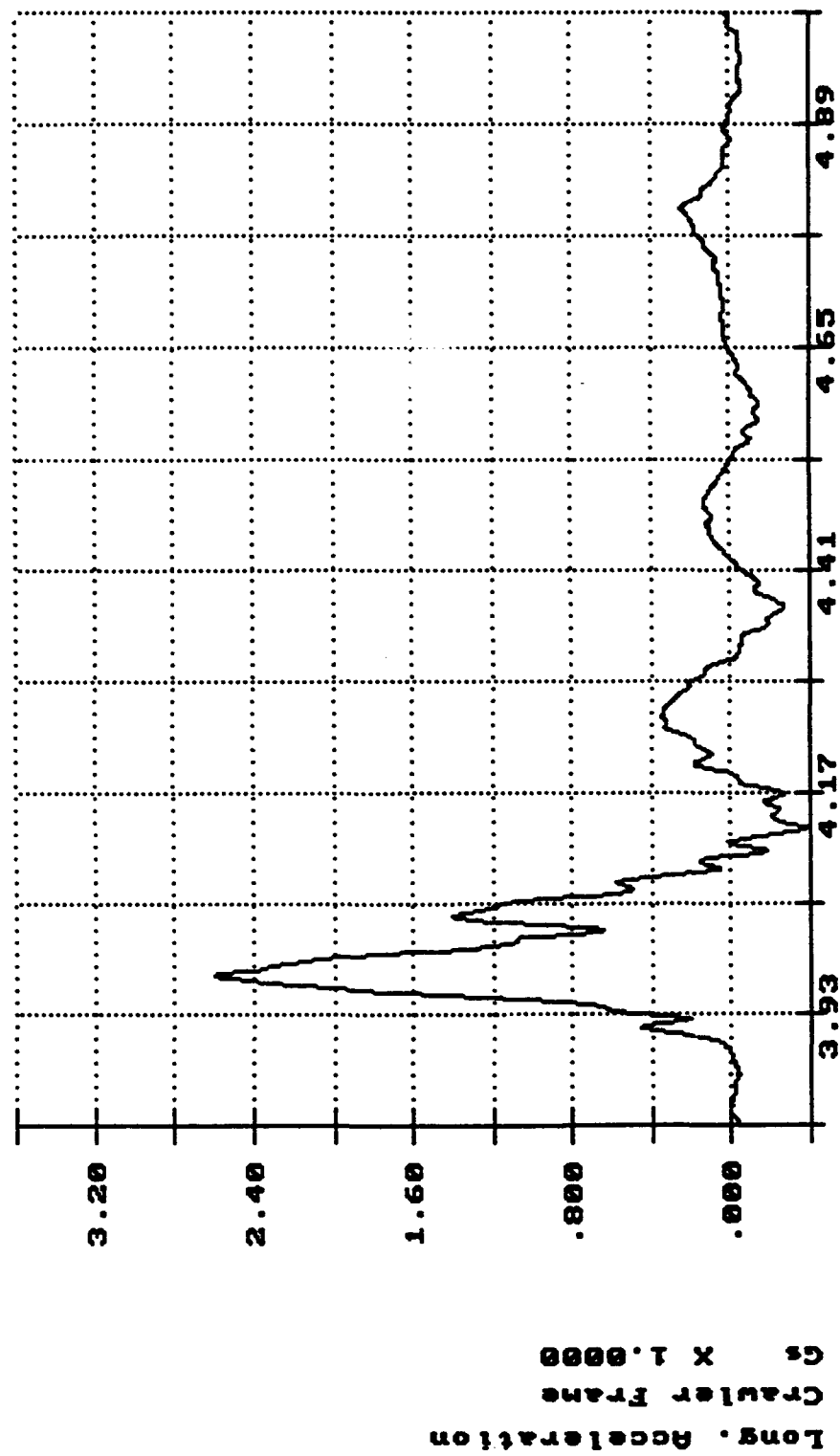
Time of Sample

Seconds X 1.0000

R.I. of Armored Crawler, #2: 6.62 MPH Jul 13 09:19:04 1993



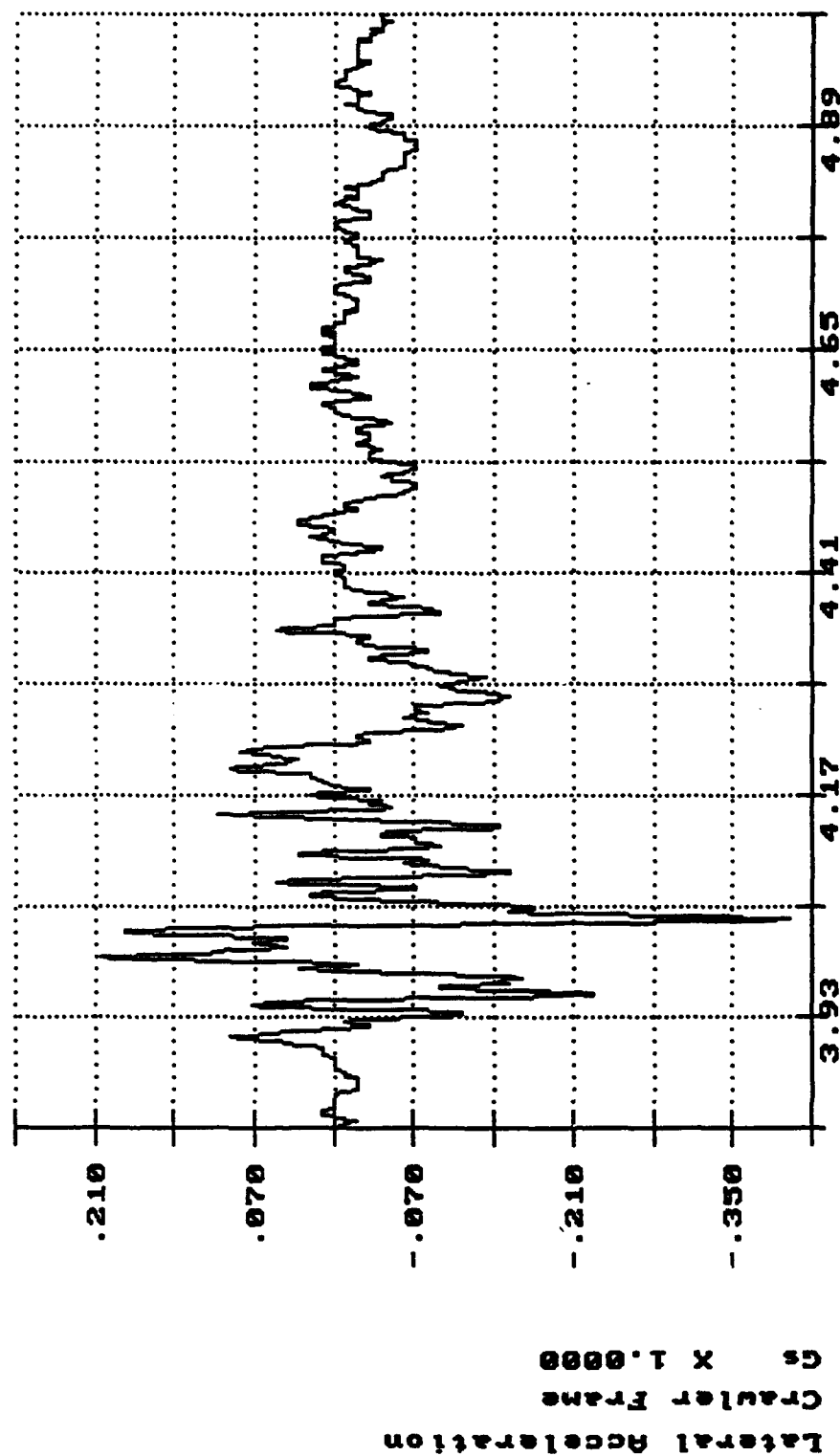
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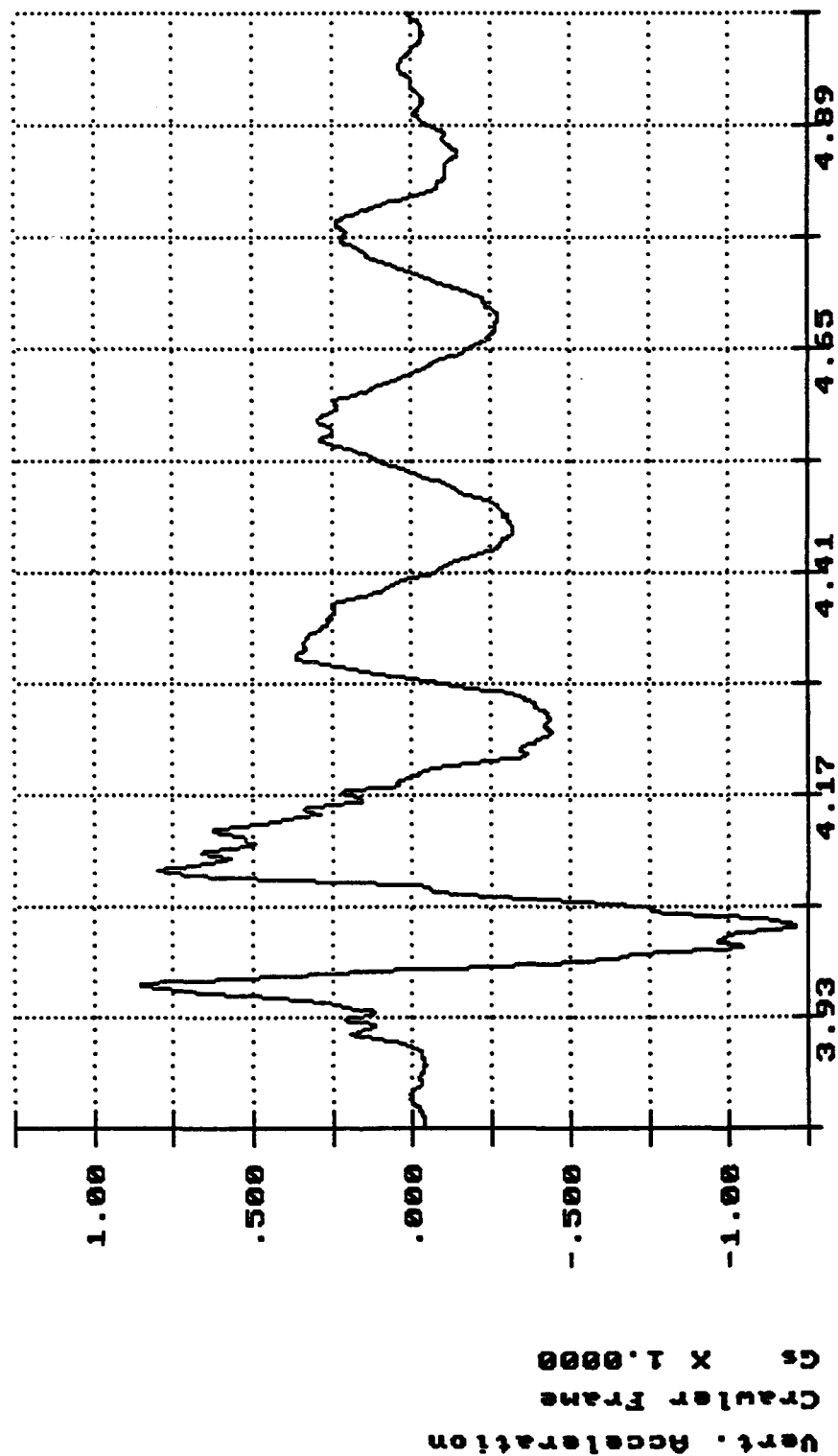
Time of Sample

Seconds X 1.0000

R.I. of Armored Crawler, #2: 6.62 MPH Jul 13 09:19:04 1993

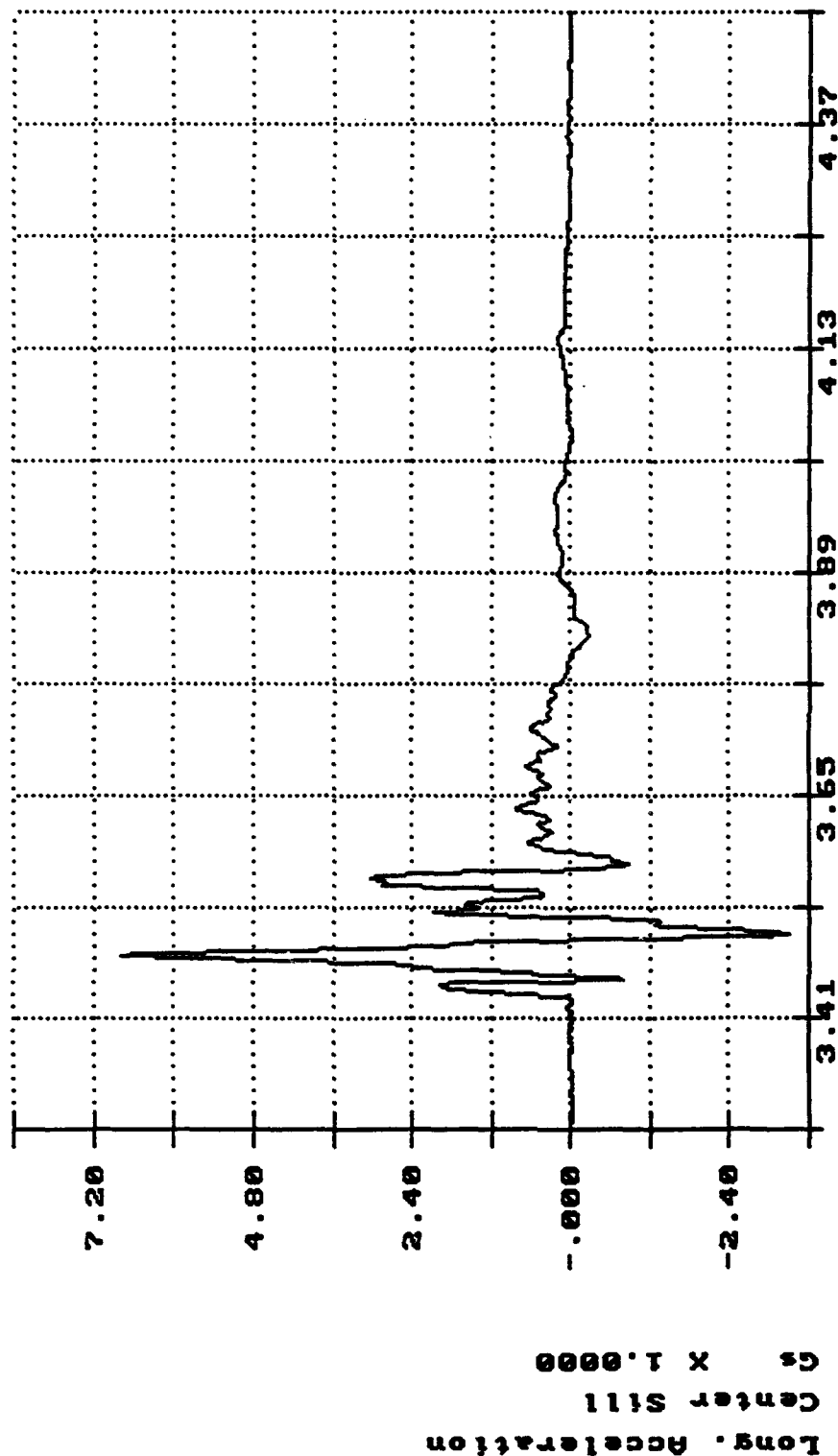


R.I. of Armored Crawler, #2: 6.62 MPH Jul 13 09:19:04 1993

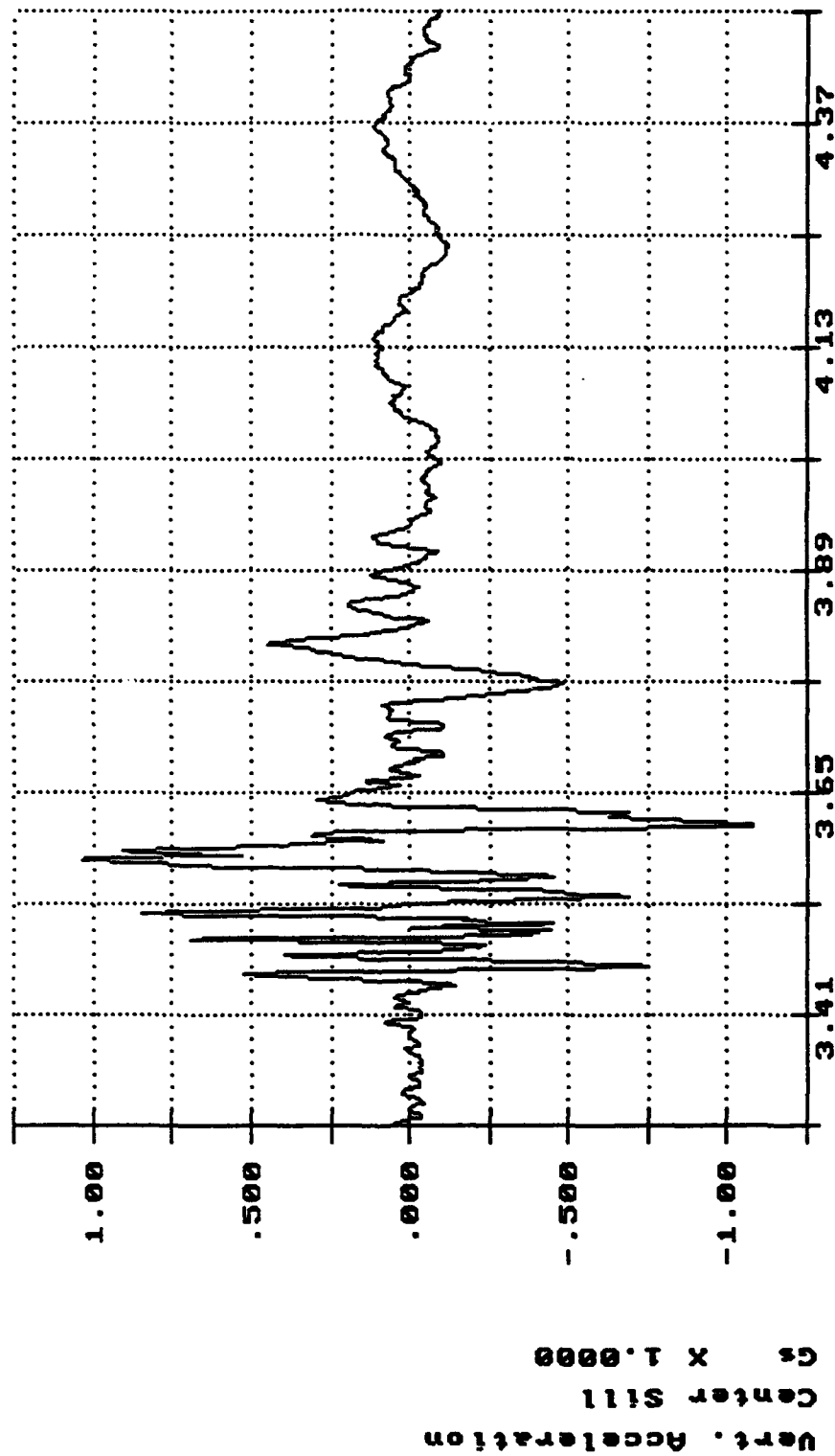


Time of Sample
Seconds X 1.0000

R.I. of Armored Crawler, #3: 8.52 MPH Jul 13 09:26:23 1993

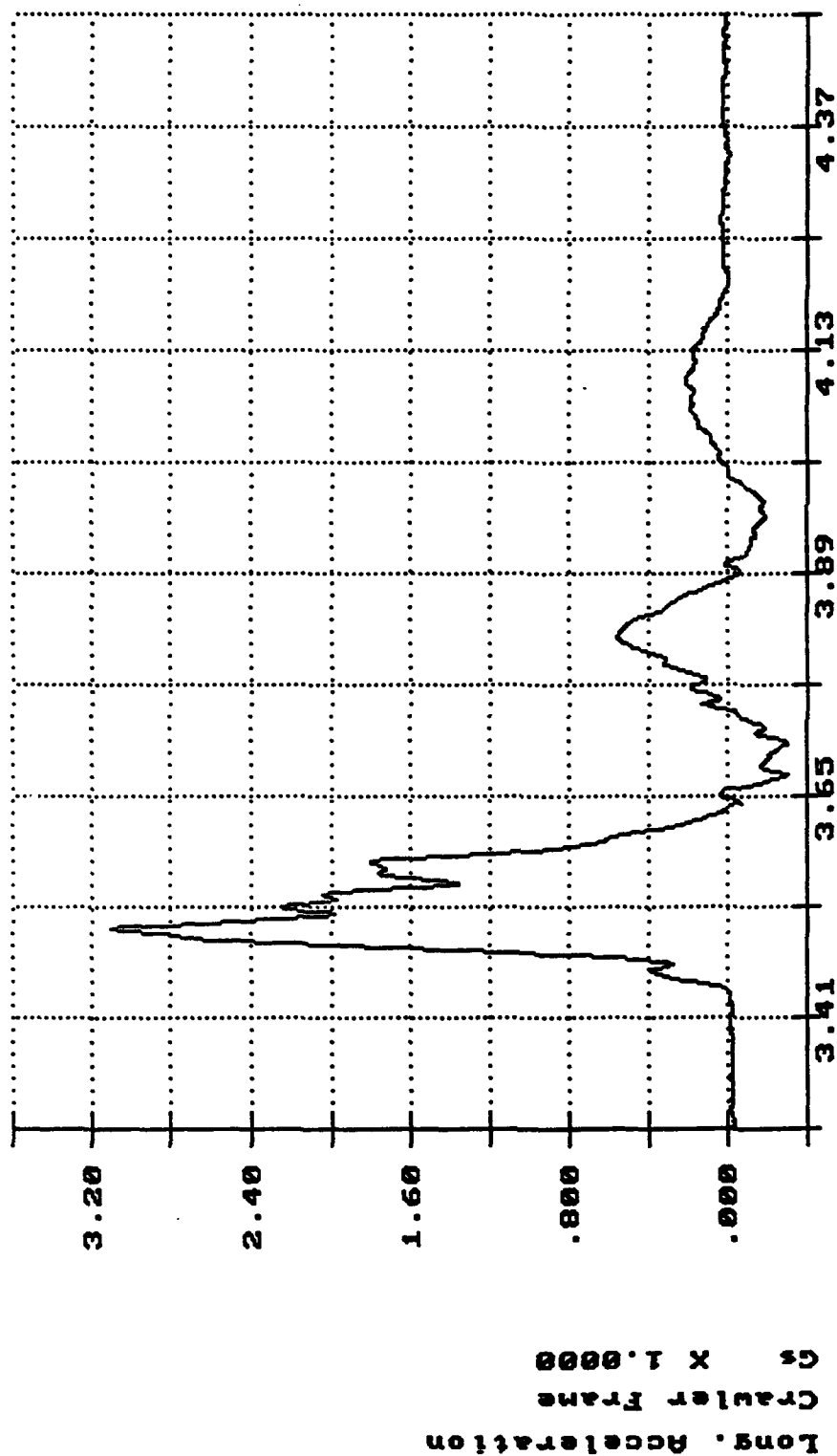


R.I. of Armored Crawler, #3: 8.52 MPH Jul 13 09:26:23 1993



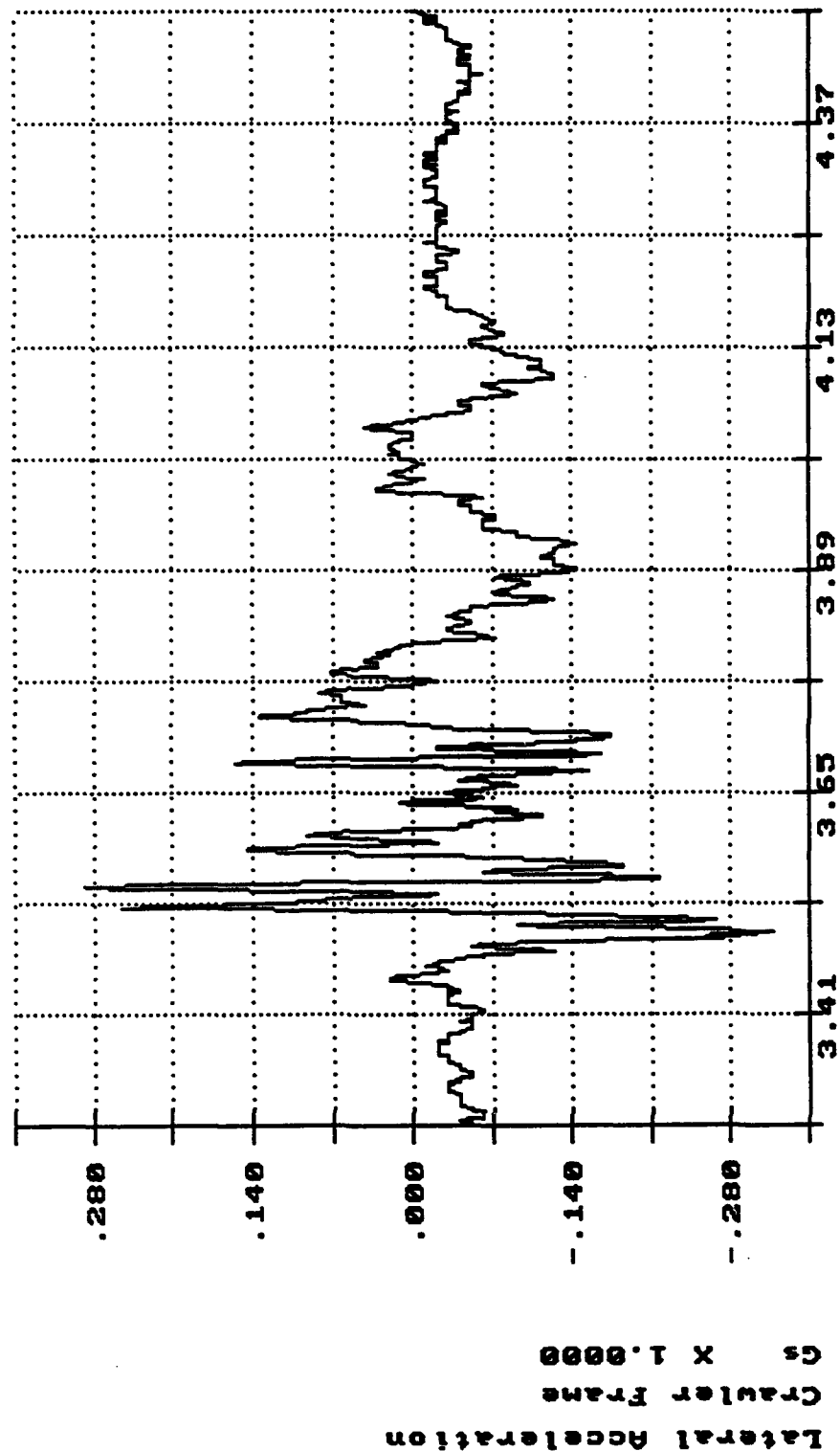
Time of Sample
Seconds X 1.0000

R.I. of Armored Crawler, #3: 8.52 MPH Jul 13 09:26:23 1993

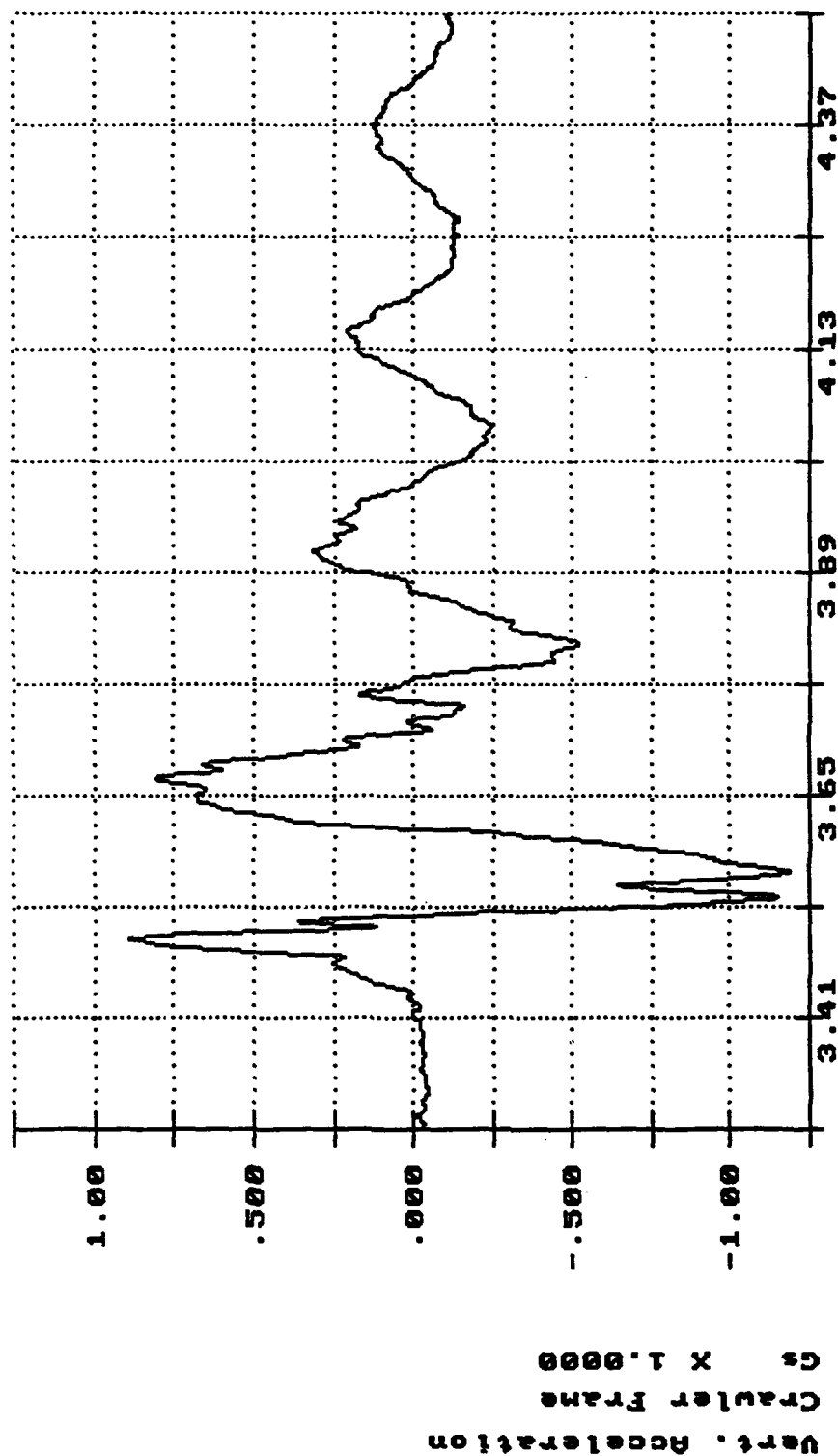


Time of Sample
Seconds X 1.0000

R.I. of Armored Crawler, #3: 8.52 MPH Jul 13 09:26:23 1993



R.I. of Armored Crawler, #3: 8.52 MPH Jul 13 09:26:23 1993



Time of Sample
Seconds X 1.0000